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Pea Diseases in the United States in 1928

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BUREAU OF
PLANT INDUSTRY
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PEA DISEASES IN THE UNITED STATES IN 1928

A report of a field study of pea diseases in the major canning and seed-producing areas of the United States made during the summer of 1928 for the Bureau of Plant Industry of the United States Department of Agriculture.

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CONTENTS

Introduction.. 2
The diseases:.. 2
    Bacterial blight.. 2
    Rootrot.. 3
    Table 1, general summary..............................4 & 5
    Downy mildew.. 8
    Black rootrot... 8
    Powdery mildew.. 8
    Mycosphaerella blight..................................... 8
    Black-leaf.. 9
    Anthracnose... 9
    Ascochyta leaf and pod spot............................... 9
    Ascochyta pinodella blight................................ 9
    Leaf-blotch... 9
    Fusarium wilt... 10
    Footrot... 11
    Stem canker... 11
    Rootknot.. 12
    Intumescences... 12
    Mosaic.. 12
    Streak.. 12
Discussion and summary.. 12

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INTRODUCTION

During the summer of 1928 the writer made an extended field study of the diseasesof peas (Pisum sativum L.) in canning and seed-producing States for the Bureau of Plant Industry, United States Department of Agriculture. A detailed report of this survey has been prepared, and copies have been deposited in the following places where they may be examined by persons particularly interested: Department of Plant Pathology, University of Wisconsin, Madison, Wisconsin; Office of Horticultural Crops and Diseases (Vegetable Diseases), Bureau of Plant Industry, Room 234, West Wing, Washington, D. C. In this summary, the attempt is made to present those findings which will be of most interest to canners, seedsmen, and plant pathologists generally.

This survey included the examination of peas for disease in each of the following 15 States: Maryland, Delaware, New Jersey, New York, Pennsylvania, Ohio, Indiana, Michigan, Illinois, Wisconsin, Minnesota, Utah, Idaho, Wyoming, and Montana. In three of these - Delaware, New York, and Wyoming - not enough fields were examined to be representative. Obviously it was impossible to make an exhaustive survey in each of the States entered, but it is believed, nevertheless, that a fairly reliable picture has been obtained of the pea-disease problems in the 12 other States listed.

Observations were made in a total of 330 fields. In all, 18 distinct diseases were recognized, many of them minor, but several of them very important factors in pea production. Fourteen was the greatest number of diseases seen in any one State.

During the progress of this study the writer received the very best of cooperation from State agricultural workers and from representatives of the commercial interests concerned. This made it possible to go directly to the most significant fields in each locality visited, including fields, frequently of known history, that were diseased or showed some abnormal condition, and fields that appeared strictly clean. Because of the selection that was thus exercised, the percentage figures in Table 1, summarizing the records of disease in different States, can not be taken as directly representative of the areas surveyed.

In the body of this report, the findings of the survey are discussed under the heading of the disease, and the diseases are arranged in order of the taxonomic position of the causal agent. This results in the intermingling of major and minor diseases. In the Discussion and Summary there is a brief capitulation based upon geographic units.

THE DISEASES

BACTERIAL BLIGHT (Bacterium pisi). Bacterial blight was found in every State surveyed during 1928 and is the only disease so distinguished. In spite of this it was relatively minor in importance this year and probably is generally of much less relative importance among diseases of the pea than the corresponding bacterial diseases are among the bean diseases. Sixty-one fields, or 18.5 per cent of all fields examined by the writer in 1928, were infested, but only a few of these contained more than traces. Some few fields, chiefly in Idaho and

Montana but not exclusively there, were damaged to the extent of 1 to 5 per cent of the yield. In such fields there was usually some complicating factor or group of factors, such as hail injury. The maximum severity observed was in one field in Illinois where Alaska peas were almost wholly ruined and Perfection peas were severely injured.

Since this disease is known to be seedborne, its frequent occurrence in the seed-producing areas of Idaho and Montana is of peculiar interest. At the present moment, however, the rather minor importance of this disease in pea-canning areas makes the seed infection problem appear rather minor too. The relation of factors other than seed infection to severe outbreaks of bacterial blight needs to be determined, for it now appears probable that such favoring factors are essential to a severe outbreak even in addition to an original source of inoculum such as the seed may provide.

During this survey, none of the stem-blight phase of the disease described by Sackett and later observed by the writer and others in Wisconsin and elsewhere has been seen. Characteristically, this year, the infection was in the form of a leaf and pod spot disease, and, when it was not limited strictly to the lower leaves of plants which appeared to have come from infected seed, its spread to other plants appeared to have occurred rather late, at a time when the infected plants were not easily damaged to a serious extent. The one notable exception to this generalization was a field in Illinois which appeared as if it had been swept by wind-blown inoculum and in which the upper and exposed plant parts more than the protected parts were almost completely covered with numerous small blight lesions.

ROOTROT (*Aphanomyces euteiches*). This disease, commonly known simply as pea rootrot, is perhaps the most widely known disease of peas in this country, and has been for several years the most destructive disease in pea-canning States. Its most serious development comes in those old intensive pea areas where heavy soil, poor drainage, relatively high precipitation, excessive application of irrigation water, or combinations of these provide the conditions of too wet soil which favor its development. Rootrot is notably a disease which becomes troublesome where peas are grown repeatedly, and hence it rarely assumes importance in new pea-growing districts.

Rootrot, as distinguished here, is a soft rot of the cortex of the root and of the base of the stem to a little above the ground line, and characteristically it affects the entire root system within a few days after infection occurs. This is in sharp contrast with the other root decay diseases spoken of here chiefly as footrot diseases, in that they are fairly localized in their attack, infecting the plant chiefly at and near the union of the taproot with the stem; in other words, in the region of the old seed. Rootrot frequently occurs in association with other diseases, including footrot, Rhizoctonia injury, and Fusarium wilt, as will be discussed under these headings. Observations on this disease made by several workers up to the present time have indicated that, in general, it is the most widespread and important factor in the phenomenon of pea-sick soil.

TABLE 1. - General summary of findings of the 1928 pea disease survey showing, by States, the number of fields examined and the number and per cent of fields infested with each disease separately.

State	Total fields examined	Bacterial blight		Rootrot		Downy mildew		Black rootrot		Powdery mildew		Mycosphaerella blight		Black-leaf		Anthracnose		Ascochyta leaf and pod spot	
	No.	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Md.	29	2	6.9	20	69.	9	31.			1	3.4	19	65.5						
Del.	2	2	100.	2	100.	1	50.					1	50.					1	50.
N. J.	6	1	16.7	6	100.	1	16.7					3	50.						
N. Y.	2	1	50.	2	100.	1	50												
Pa.	13	2	15.4	4	30.8	2	15.4					3	23.1						
Ohio	10	4	40.	3	30.	3	30.											1	10.
Ind.	18	1	5.6	2	11.1														
Mich.	15	2	13.3	4	26.6	1	6.7											6	40.
Ill.	18	9	50.	4	22.2					3	16.7	3	16.7						
Wis.	42	2	4.8	21	50.	18	42.8					2	4.8			4	9.5	2	4.8
Minn.	10	1	10.	5	50.	4	40.			1	10.	1	10.						
Utah	16	1	6.2	12	75.	7	43.7							1	6.2				
Idaho	89	22	24.7	19	21.4	16	18.	1	1.1					8	9.				
Wyo.	3	2	66.6																
Mont.	57	9	15.8	30	52.7	10	17.5					3	5.3	2	3.5			4	7.
Totals and averages	330	61	18.5	134	40.6	73	22.1	1	0.3	5	1.5	35	10.6	11	3.3	4	1.2	14	4.2

TABLE 1. - Continued

States	Ascochyta pinodella blight		Leaf - blotch		Fusarium wilt		Footrot		Stem canker		Rootknot		Intumes- cences		Mosaic		Streak		Total diseases observed
-	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Md.	1	3.4			5	17.2	12	41.4							15	51.7	12	41.4	10
Del.																	1	50.	6
N. J.							4	66.6	1	16.7			1	16.7	3	50.	3	50.	9
N. Y.																			3
Pa.	2	15.4	4	30.8	6	46.2	3	23.1											8
Ohio	1	10.			5	50.	2	20.	2	20.									8
Ind.					4	22.2	15	83.4	1	5.6					2	11.1			6
Mich.	2	13.3	2	13.3					2	13.3									7
Ill.			2	11.1	14	77.8	2	11.1											7
Wis.	11	26.2	8	19.	22	52.4	9	21.7					1	2.4	1	2.4	1	2.4	13
Minn.			1	10.			4	40.	4	40.					1	10			9
Utah															6	37.5	4	25.	6
Idaho			7	7.9	8	9.	12	13.5	4	4.5	1	1.1			8	9.	10	11.2	12
Wyo.															2	66.6			2
Montana	5	8.8	27	47.4	3	5.3	3	5.3	2	3.5			1	1.8	8	14.	11	19.3	14
Totals and averages	22	6.7	51	15.5	67	20.3	66	20.	16	4.8	1	0.3	3	0.9	46	13.9	42	12.7	18

Rootrot was found more widespread and abundant in 1928 than any other disease, occurring in almost as many fields as any other two diseases together. In all, 134 fields were found infested, or 40.6 per cent of all fields examined; and in 50 per cent of the diseased fields over half the area was infested. With the exception of Wyoming, where only three fields were examined, rootrot was seen in every State visited.

In the area comprising New Jersey, Delaware, and the Eastern Shore of Maryland, rootrot was abundant in old pea fields, occurring more frequently than any other disease and often in very heavy infestation. In spite of this, however, losses generally were relatively mild. In Maryland, rootrot and Mycosphaerella blight frequently occurred together, and of the two the latter was the more important this year, as, in the opinion of A. D. Radebaugh, it has been for several years. In a few fields rootrot took losses of 50 per cent of the crop, but at the other extreme some infested fields were scarcely damaged at all. In Delaware, the only two fields examined were heavily infested with rootrot, but the injury was slight. In New Jersey, rootrot was abundant and, in some instances, severe; but the work of C. M. Haenseler is showing that with proper culture and fertilization the losses are not so severe as to make the crop unprofitable.

The situation in western Maryland and southern Pennsylvania was distinctly different. Rootrot was present in several fields, causing losses which amounted to as much as 20 per cent of some crops, but in such fields the Fusarium wilt was almost always much more destructive, making rootrot relatively minor in local importance. Serious pea failures here in recent years appear to have been the result of wilt rather than rootrot.

In New York, where observations were limited to two plantings, both were infested. A commercial field at Geneva was almost completely destroyed by this disease, and a garden planting at Yonkers was distinctly weakened.

In the areas visited in southern Ohio, northern Indiana, and central and northern Illinois, rootrot was found widely distributed and sometimes important in association with other diseases, notably Fusarium wilt. Important losses from rootrot were limited to fields that had been replanted many times with peas and chiefly to fields that were excessively wet - too wet for the best growth of peas anyway.

Rootrot was the one important disease seen in Michigan this year, and it was apparently not a very serious factor. Root drowning in excessively wet soil led to serious losses in the absence of the rootrot fungus.

In Wisconsin, conditions were not notably changed from those observed during recent years, except that rootrot was distinctly less severe in north-central Wisconsin under the influence of a season somewhat drier than usual during the critical period. In the limited area of south-central Wisconsin that was examined this year, rootrot was seen repeatedly but seldom in very severe development. Wilt was here more important by far than this disease. In the extreme eastern part of the State, excessive rainfall combined with naturally wet soil types to make the injury from rootrot most extreme.

In Minnesota, rootrot was seen in five of the ten fields examined, but in the State as a whole it was of practically negligible importance, for the survey included the fields and localities most likely to be infested. The one field that was thoroughly infested had suffered only moderate injury up to the time it was examined.

In the past, rootrot has been regarded as of minor importance in the Rocky Mountain States generally. This present survey indicates both greatly increased prevalence and greater severity than heretofore observed, especially in Utah and Montana.

In Utah in 1928, rootrot was distinctly more abundant than recorded by the writer for 1927, infesting many fields thoroughly and causing injury which varied from that so slight as to be negligible up to the utter destruction of the crop; losses of 20 to 40 per cent were frequent in these fields. In the Weber and Ogden valleys, every field examined was infested. This marks a pronounced increase since 1921 and 1923, when Fred R. Jones found the rootrot parasite here in small amounts only. The Cache Valley still appears entirely free from this disease, though there is no reason to think it will long remain so.

In Idaho, rootrot was important in very few fields. Although it is scattered sparingly over practically the entire upper Snake River Valley wherever peas have been grown many years, only very few fields are infested and no locality shows any threat of severe infestations. In only a single field did the loss amount to 25 per cent of the crop, and this was a field that had been notoriously overcropped with peas. As in Utah, rootrot has been known here since 1921, but unlike in that State there has been no notable increase. This year only 19 fields were seen to contain even a trace, and visible injury was limited to wet fields and wet parts of fields, which are not common in this part of Idaho. Cropping practices which would be suicidal in other parts of the country are often followed here without trouble from rootrot.

Montana presented a set of conditions more like those described for Utah. Of the 57 fields examined in this State, 30 fields or 52.7 per cent were infested, and of these infested fields, 80 per cent were diseased throughout at least half of their area. These diseased fields were scattered through all the districts included in this survey, including the Gallatin Valley, the Paradise Valley, and the districts around Red Lodge and Bridger. In each of these areas, fields were observed in which the crop was almost wholly destroyed, and, while the severity of injury was highly varied from field to field, it was clear that this disease is notably reducing the average yield per acre in this State. Since earlier surveys in Montana in 1921 and 1923, the amount of this disease has increased greatly, until now it appears that cropping practices must be revised if pea culture is to continue without the handicap of an annual toll levied by rootrot.

Considering as a unit the entire area covered by the survey, rootrot was distinctly the most destructive disease affecting the pea crop in 1928. Its local importance frequently escapes the attention of pea growers and even field supervisors of canning and seed companies. In the irrigated districts, for example, it is the common thing to attribute the injury done by rootrot to excessive irrigation or to the crowding of weeds. Evidence gathered during this survey indicates that the rootrot fungus is still spreading and suggests that it may continue to spread until those areas in which environmental conditions and cropping practices favor its development become thoroughly infested. On the other hand, it appears that certain areas, such as parts of south-central Wisconsin, are now pretty thoroughly infested but still are not subject to severe losses from rootrot except in very wet years. There is pressing need for an analysis of the factors which lead to the notable variations in severity of injury from rootrot even in the presence of thorough decortication of the roots, with the hope that some means may be devised for the avoidance of the more severe types of injury.

DOWNY MILDEW (Peronospora viciae). This is one of the most widespread and least important diseases of the pea. During 1928 it was seen in all States surveyed except Indiana, Illinois, and Wyoming, and in 22.1 per cent of all fields examined. In nearly all of these fields it occurred in mere traces, and the maximum injury noted was only 2 per cent. In most of the infested fields this disease occurred only in the form of rectangular conidial patches on the leaf laminae, varied by the occasional occurrence of yellowish-white, porcelaneous, slightly swollen areas on leaves, stems, and pods, where the oospores of the fungus are developed. A further variation is the development of an apparently systemic infection, but this was seen less frequently this year than formerly in Utah and Wisconsin. One of the most interesting consequences of this disease is the facility with which other organisms enter downy mildew patches as secondary parasites, leading to early necrosis of the infected tissue, which ordinarily does not follow the invasion of Peronospora alone. The secondary invaders observed during the survey are: Ascochyta pisi, A. pinodella, Bacterium pisi sp., and Cladosporium sp. For the present, at least, there is no reason why this mildew should be of concern to either seedsman or canner.

BLACK ROT (Thielavia basicola). A few plants affected with a black rootrot collected in a field at Rexburg, Idaho, proved upon microscopic examination, to bear chlamydospores of Thielavia in great numbers upon the blackened surfaces. Although the writer examined many other root collections from this same locality, no other spores of this fungus were encountered. This fungus has been reported on peas several times without adequate evidence that it is ever aggressively pathogenic, but this is the first time the writer has observed it.

POWDERY MILDEW (Erysiphe polygoni). This disease was observed in traces only in a total of five fields in Maryland, Illinois, and Minnesota. Its known range is much wider than this.

MYCOSPHAERELLA BLIGHT (Mycosphaerella pinodes). During these present studies this blight, which formerly was confused with the disease caused by Ascochyta pisi, was found in 8 of the 15 States visited, as listed in the general tabulation of survey findings, Table 1. These States do not represent the total known range of the fungus in this country. As with other seedborne diseases, this blight is probably very widespread, but in recent years generally it has not been conspicuously important except in a few localities. L. K. Jones reported severe outbreaks in New York State in 1926, unequalled there since that year.

In 1928 the only destructive local outbreaks were found in eastern Maryland and vicinity. Here it was the most destructive disease present, causing losses estimated to be as great as 35 per cent in some fields. In the opinion of A. D. radebaugh this has been the most important disease factor in this area for several years. In other parts of the country Mycosphaerella blight was both rare and mild. The only other noteworthy occurrence was in Montana, where it was not expected at all and where three fields were lightly infested.

Although the seedborne nature of this disease has been clearly established and was supported by additional observations during this survey, still it is obvious that the planting of infected seed was not the most important immediate factor this year inducing the destructive development of this blight. The seed used in the badly blighted fields of eastern Maryland and vicinity came almost exclusively from Idaho and Montana, where this disease is very rare. On the other hand, the severe outbreaks occurred almost exclusively where peas had been grown repeatedly on the same field or on adjoining fields. It seems clear that the neglect of crop rotation and reasonable farm sanitation are more important in the development of severe outbreaks of this disease than the simple use of infested seed. Infested seed may introduce the fungus, but faulty cropping practices coupled with favorable weather will give it an opportunity to increase to the point of becoming destructive.

BLACK-LEAF (Fusicladium pisicola). Black-leaf was observed in traces only in a total of 11 fields in Utah, Idaho, and Montana. This is the first time it has been found in Montana. Areas in Idaho and Utah where it has been seen in past years were practically or completely free from it.

ANTHRACNOSE (Colletotrichum pisi). Anthracnose was found only within its formerly known range in Wisconsin, and was not seen to cause any important injury.

ASCOCHYTA LEAF AND POD SPOT (Ascochyta pisi). This disease, until recently confused with the Mycosphaerella blight, was of very minor importance in the area surveyed during 1928. It was seen in only 14 fields, and was abundant in only two fields of a seed-trade variety in the Paradise Valley of Montana. In several fields this disease occurred chiefly or exclusively in association with downy mildew.

ASCOCHYTA PINODELLA BLIGHT (Ascochyta pinodella). This blight is closely similar to that caused by Mycosphaerella pinodes but is less destructive; in fact, it appears to be almost negligible. It was seen during 1928 in only six States, although formerly observed also in Utah by the writer. Apparently the parasite is not an aggressive invader of the healthy pea foliage, for in several fields the only points of infection seemed to be within downy mildew patches from which the blight lesion then extended into healthy tissue. The chief interest in this disease lies in the fact that the parasitic fungus is one of the most widespread causes of footrot, and that the pod infection sometimes associated with this blight is a factor in the seedborne aspect of the footrot disease.

LEAF-BLOTCH (Septoria pisi). Leaf-blotch was relatively minor in most of the States surveyed in 1928, but developed so abundantly in Montana that in the country as a whole it was the third most frequently observed disease of aerial parts. Of the 51 fields which were seen to contain this disease, over half were in Montana, where 47.4 per cent of all examined fields were infested. In the country as a whole, both downy mildew and bacterial blight were seen in more fields, but neither was as important as this blotch. Throughout most of its range only traces of blotch were found; in Wisconsin, however, several fields were damaged very badly, and in Montana important injury was seen in many fields. The actual injury could not be estimated because in every case of severe leaf-blotch other diseases, such as rootrot and wilt, occurred with it in destructive infestation, but the condition of almost complete defoliation before the seed crop was mature was observed repeatedly. Whether this disease is favored by a weakened condition of the plant or whether its frequent occurrence with other diseases results simply from the fact that all are more frequent where peas have been grown too intensively remains to be determined.

FUSARIUM WILT (Fusarium orthoceras var. pisi). Fusarium wilt, a disease that has been under observation only since 1924, when it was first differentiated from the pea failure complex in Wisconsin, is now, next to rootrot, the most destructive disease of peas in this country and, from the standpoint of its potential importance to the pea industry, it is at least equal to rootrot. Previous to this survey wilt had been reported only from Wisconsin, Michigan, and Indiana, but now it is known to occur in nine States, including,in addition to the three mentioned, Maryland, Pennsylvania, Ohio, Illinois, Idaho, and Montana. Unconfirmed reports suggest that it occurs also in California.

Sixty-seven fields, or 20.3 per cent of all fields examined, contained wilt. Two diseases were found more frequently: Rootrot and downy mildew; and footrot was found almost as often. But losses from wilt are much greater in proportion to the number of fields infested than in the case of these other diseases, for wilt infestations are frequently heavy, and in the infested fields or parts of fields the crop is usually a total loss.

In the survey of 1928, wilt was not found in New Jersey, Delaware, and Eastern Maryland. In western Maryland and southern Pennsylvania, however, it was the one outstandingly important disease. In the survey of this area wilt was found in 11 fields, causing losses of over 50 per cent in several fields and as much as 80 per cent in one large planting. In the opinion of A. D. Radebaugh and certain canners, this is the one disease that has caused trouble here for several years.

While no wilt was seen in New York State, observations were too limited to indicate its absence. L. K. Jones, who has followed pea-disease developments for several years, has reported none of it.

In southern Ohio, northern Indiana, and central and northern Illinois, rootrot and wilt were both found in 1928, but wilt appeared to constitute the major pea-disease problem. Wilt caused heavy losses in some areas in each of these States and apparently has been doing so to an increasing extent for some years. In areas of northern Illinois where a few years ago there was no important disease problem, wilt is now causing heavy losses. In one district where the writer saw several fields that were almost totally ruined, it was reported that 200 acres were severely damaged by this disease. In Michigan, although wilt is known to occur on the Northern Peninsula, none was found in the areas surveyed this year.

As has already been pointed out, wilt in Wisconsin in 1928 showed a distinctly increased prevalence over the conditions observed in 1924 and 1925. No attempt was made to cover new territory in this State; attention was concentrated in localities with which the writer was familiar from earlier field studies. A trace of wilt was found in 1928 in one area in north-central Wisconsin where none was formerly present, and in the more southern districts where wilt was known earlier it was found in greater abundance than formerly. It is of special significance that in these districts certain fields that had contained small amounts of the disease in 1924 or 1925 were this year thoroughly infested, even though no peas had been grown there during the interval of years. In no case did crop rotation appear to be of any assistance after the wilt fungus was once established

Plant Disease Survey.

in the field.

None of this wilt disease could be found in either Minnesota or Utah.

One of the most significant and perplexing results of the survey was the finding of wilt in both Idaho and Montana, the States which supply the bulk of the seed used in the pea-canning industry. Wilt was not known formerly to occur in any of the Rocky Mountain States. In the upper Snake River Valley of Idaho it was seen in two localities. In one it was found on two nearby farms; in the other it was abundantly distributed over numerous farms, causing the complete destruction of the crop in one large field and the loss of parts of several other crops. In Montana, wilt was seen in two widely separated localities in the Gallatin Valley: a mere trace in one, and two infested farms in the other. At present the losses from wilt in these two States are not startling, and yet the severity of injury in infested fields is the same as in Wisconsin and elsewhere: susceptible varieties are eliminated completely. It is clear, therefore, that nothing in soil or climate stands in the way of very destructive development of this disease. Opportunities for the dissemination of the wilt fungus seem rather unusual here, arising from the practice of irrigation and from the use of pea-vine straw as feed and bedding for livestock.

There is no experimental evidence to indicate that the wilt fungus is ever carried with pea seed, but this question has not yet been adequately studied. Nevertheless, the establishment of so destructive a disease in the heart of two major seed-pea areas is of direct concern to both seedsmen and canners, and serves to emphasize the need for speedy perfection of suitable wilt-resistant varieties of peas.

FOOTROT (Ascochyta pinodella, Fusarium martii var. pisi, and other fungi). Several fungi, of which the two named here predominate in this country, produce disease symptoms that can not be differentiated in field examination, and therefore they are considered together here. Under this name of footrot are grouped those cortical rot diseases in which the injury is more or less localized, beginning as a dark brown decay in the region of the old seed and spreading upward onto the base of the stem below ground and downward over the hypocotyl a short distance onto the roots. The Ascochyta pinodella disease, at least, is seedborne to some extent.

Footrot is frequently associated with and confused with wilt and rootrot, but it is much less important than they are. During 1928 it was seen in 66 fields, or 20 per cent of all fields examined, occuring in traces in most of these but in heavy infestations in a few. Footrot may be expected almost everywhere that peas have been grown for a period of years, although it may not be recognizable if associated with rootrot. In general its importance is very minor, but in one field in Idaho a very severe footrot, caused apparently by a species of Fusarium, had caused a 60 per cent loss of stand and a notable weakening of the surviving plants.

STEM CANKER (Rhizoctonia). This disease was found widely distributed but nowhere very abundant. It was recorded in seven States from New Jersey to Montana in 4.8 per cent of all fields examined. In only a few of these did it cause any apparent independent injury. In making microscopic examinations of roots affected with various diseases, mycelium of Rhizoctonia is frequently observed. Its significance when associated with Aphanomyces and with the footrot fungi is not understood.

ROOTKNOT (*Heterodera radicicola*). This nematode injury was observed in a single field near Idaho Falls, Idaho, where it occurred in a small area within an old potato field. Affected plants were stunted and yellow.

INTUMESCENCES (Water relations). This curious condition, described by Sorauer, was seen on a few plants in a single field of Alaska peas in each of New Jersey, Wisconsin, and Montana. On affected plants all the pods usually develop succulent, prong-like outgrowths of variable form and size. Other parts of the plant are sometimes affected similarly.

MOSAIC (Cause undetermined). Mosaic of the pea has been known for some years but has not been important in commercial plantings. In 1928 it was widely distributed; it was seen in 46 fields, 13.9 per cent of all examined, in nine States from the Atlantic Coast west to Utah and Montana. Both in abundance and severity it reached its maximum in Maryland and New Jersey. From there west to the Rocky Mountains it was very rare; and then in Utah and Montana it was moderately abundant. Except in a few eastern fields, however, where infestations sometimes exceeded 5 per cent and where diseased plants showed diminished yields of deformed pods, the occurrence of this disease was of no economic importance in 1928.

One special case of unusual mosaic symptoms that merits mention was observed in New Jersey. In a single field there was found an area about one rod in diameter in which a large percentage of the plants showed a brilliant yellow and green calico mottling of a type quite different from the usual mosaic mottling on peas. This calico effect was noted even on the pods which showed less striking color contrasts but which were conspicuously discolored and deformed. Even the peas within these pods were yellow or mottled yellow and green. This trouble was of such apparent severity as to be cause for concern if it should reappear and spread in subsequent years.

STREAK (Cause undetermined). This little known disease, which bears a marked resemblance to certain virus diseases of other plants, was found throughout essentially the same range as pea mosaic. It occurred in somewhat fewer fields, but in infested fields the amount of streak averaged greater than of mosaic. Streak is characterized by necrosis of pods and of the phloem in stems and leaves, and, occasionally, necrosis of the entire upper portion of the plant. No micro-organisms have been found associated with this condition.

DISCUSSION AND SUMMARY

For the convenience of the reader, the following recapitulation presents the major disease problems, as observed in 1928, by States or larger geographic units:

In eastern Maryland and vicinity, Aphanomyces rootrot and Mycosphaerella blight are the two outstanding diseases and frequently occur together. In some localities rootrot occurs alone; and in some the Mycosphaerella blight is the most destructive disease. Footrot was abundant in a few fields, and mosaic and streak were more prevalent here than anywhere else in the States surveyed.

In western Maryland and southern Pennsylvania, Fusarium wilt was the one seriously destructive disease. Rootrot was distinctly less abundant than farther east, and Mycosphaerella blight was almost absent.

In southern Ohio, northern Indiana, and central and northern Illinois, rootrot and wilt occurred together, but wilt appears to have been the major disease problem for some years. Rootrot appears to be limited to fields wetter than average and to be generally of minor importance. Of the minor diseases sometimes found, footrot was especially abundant in one locality in Indiana, and bacterial blight was seriously destructive in a large field in Illinois.

In Michigan and parts of Wisconsin, rootrot is the most destructive disease of the pea. In other parts of Wisconsin, Fusarium wilt is unrivaled by other diseases. In some areas wilt has increased notably in its prevalence since 1924 and 1925. Many other diseases occurred in Wisconsin this year as formerly, but most of them were of no great economic importance although a few became destructive locally.

In Minnesota, very little disease was found. Rootrot was seen several times, but the injury apparent at the time of the survey was slight. Footrot and some other diseases were noted, but no wilt was seen.

Rootrot was distinctly more abundant in Utah than reported by the writer to have been in 1927. In some localities practically every field was infested, but the severity of injury was highly varied. No wilt was detected, and diseases of aerial parts were relatively rare, with the exceptions of the unimportant downy mildew, mosaic, and streak.

The States of Idaho and Montana are of special interest because of their being centers of pea seed production. As might fairly be expected, these States are no longer free from disease. They were, in fact, among the three States which displayed the greatest numbers of different diseases. Most of these diseases, however, were present in relatively small amounts, and some of them in mere traces. Of the major diseases, rootrot was the most prevalent, especially in Montana, where it caused heavy losses in some fields. In the larger portion of the seed area, however, it is rare or absent. Fusarium wilt was found to be established in both States and constitutes a problem that must be given attention to insure the permanence of profitable pea production. Of the several diseases which are known to be carried on the seed, only bacterial blight occurred frequently. In Montana, the leaf-blotch disease reached its maximum destructiveness, and constitutes a problem that needs local study. Mosaic, streak, footrot and other minor diseases were recorded frequently.

To summarise the outstanding points of this field study, rootrot and Fusarium wilt were found to be the two most important diseases of the pea throughout the area studied, although many other diseases ocurred occasionally and sometimes became troublesome locally. Rootrot has been known to occur widely for some years, and the present findings indicate that while certain areas are now free, it is still spreading, and that in certain areas where it occurred in small amounts only a few years ago it has increased markedly in prevalence and severity. On the other hand, in some areas where it has long been known, rootrot has not become an important factor.

Fusarium wilt, which formerly was reported only from Wisconsin, Michigan, and Indiana, has now been found widely distributed. Throughout much of its range it occurs sparingly and appears to be of recent introduction, but wherever it has been found it shows its normally great severity. In central Wisconsin, where wilt has been known longest, it has shown a marked increase in prevalence during the five years since it was first discovered. It is clear that wilt has not yet attained its ultimate geographic range. Its potential importance is such that wilt, more than any other disease of peas, demands immediate attention looking towards the perfection of disease-resistant varieties and the devising of supplementary means to avoid losses.